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Application of the Derivative Concept to Determine the Maximum Profit Point of *Nasi Lengko* Traders in Cirebon

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ABSTRACT

This study employs the concept of differentials, or mathematical derivatives, to determine the maximum profit points for Cirebon-style Nasi Lengko UMKM, namely Trader A and Trader B, both located in Sunyaragi Village. The study employs a quantitative descriptive approach, using interview data on capital, selling price, revenue, and production quantity. The data are then formulated as functions of total cost, revenue, and profit, using the first derivative to identify the critical points and the feasible domain. The results show that Trader A, with a capital of Rp 101,000 and a capacity of 20 portions, obtains a maximum profit of Rp 99,000 when all production is allocated to egg Nasi Lengko priced at Rp 10,000 per portion, due to a constant negative derivative. Meanwhile, Trader B, with a capital of Rp 200,000 and a capacity of 40 portions, achieves a maximum profit of Rp 200,000 by producing Nasi Lengko at a price of Rp 10,000 per portion, with a constant positive derivative. This study demonstrates that the concept of derivatives can help optimise production decisions in traditional food UMKM, despite limitations such as a small sample size and limited variable-cost data. Further studies are recommended to use a wider sample and more comprehensive data.

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1. INTRODUCTION

Mathematics is a science related to numbers and logic that has practical applications in everyday life, helping solve problems such as calculating profit and loss, determining building size and more. In addition, mathematics also helps develop critical thinking and problem-solving skills, enabling people to analyse situations logically and make sound decisions in various aspects of life [1]. In the field of economics and business, the problem can be addressed using mathematics, specifically by researching the concept of derivatives, which are used to calculate the maximum and minimum values of profit, loss, cost of goods or capital, and daily income costs of the business. With this, the existence of a derivative concept can help to solve problems in the field of economics and business in seeking maximum and minimum profits [2].

On the other hand, many Usaha Mikro, Kecil, dan Menengah (UMKM) in Indonesia, including traditional food vendors, still rely on their own experience and estimates to determine selling prices and production quantities. This often leads to an imbalance between costs and revenue, ultimately resulting in low profits. This situation also occurs among *Nasi Lengko* traders in Cirebon. *Nasi Lengko* is a regional speciality that has many competitors and varying market prices. *Nasi Lengko* traders naturally determine selling prices and production quantities based on daily habits, without using more scientific methods to determine the maximum profit point for a specific production quantity at which revenue minus costs reaches its highest value. Therefore, the use of mathematical methods can help traders make more effective decisions and reduce the risk of losses from overproduction or underselling [3].

The results of previous research also stated that the concept of derivatives can help in calculating profits by connecting total costs, production costs, selling price costs and the number of products produced. In Qurani's research with "Analisis Keuntungan Maksimum UMKM Rumah Makan Kita Menggunakan Aplikasi Turunan (Derivatif)," using the concept of derivatives in restaurants by finding the first and second derivatives, with the maximum profit results obtained when the production amount is equal to the critical point value [4]. However, when production results are added, profit decreases due to rising production costs. Then, in Puspaningrum's research with the title "Aplikasi Deferensial dalam Menghitung Analisis Keuntungan Maksimal pada UMKM," still using the same concept but with a different method, the research was conducted on Dewi Chips UMKM in Sambosar Raya Village, Simalungun, where the results of the study stated that only some of its products achieved maximum profits. In contrast, other products could not achieve maximum profits due to their selling prices and production volumes [5]. From the research, gaps include the absence of similar studies examining maximum profits in traditional food, the lack of attention to market competitors in the area, and the failure to account for varying market prices.

Therefore, this study focuses on applying the concept of derivatives to determine the maximum profit for *Nasi Lengko* vendors in Cirebon. This study aims to demonstrate how mathematical concepts can be directly applied to everyday economic activities and demonstrate that mathematics is not merely an abstract theory but also useful in real life.

2. METHOD

The method used in this study is quantitative and descriptive. The quantitative method is based on the philosophy of positivism and is used for research on numerical data and for statistical analysis of samples and populations [6]. Meanwhile, the quantitative descriptive approach describes a variable used in the study, the data is obtained directly from the research and the variables are based on data in the form of numbers whose results are real without manipulation [7]. The study was conducted on UMKM *Nasi Lengko* traders, Trader A and Trader B, located at Bima Stadium, specifically in Sunyaragi Village, Kesambi District, Cirebon City. The instrument used was an interview with the source of *Nasi Lengko* traders, asking about Nasi Lengko, business capital, income, and so on, to obtain variables and data for the study.

From this research, procedures must be followed to process most of the data obtained. This data processing will go through a procedural stage to calculate tabulated data and implement derivative applications, therefore requiring a mathematical formula with stages to determine it. The following stages are [5]:

1. Total Cost (TC) Function
   The first step is to identify the two main cost components:
   - Fixed costs (FC) → costs that remain constant regardless of changes in production volume (e.g., rent, equipment).
   - Variable costs per unit (VC) → costs that depend on production volume (e.g., raw materials per serving).

   Identifying cost components, including fixed costs and variable costs per portion (variable cost/VC), so that the total cost function can be formulated as:
   $TC(x) = FC + VC \cdot x$
   Notes:
   x = quantity produced (units)
   FC = fixed costs
   VC = variable costs per unit
2. Revenue Function (Total Revenue / TR)
   Revenue is derived from product sales.
   a. A single product
      Compile the revenue function (R) based on the selling price per portion and production quantity, so that the function is obtained:
      $TR(x) \; = \; P \cdot x$
   b. Two types of products
      If there are two products with a total production capacity of T, then:
      $R(x) = P_1 \cdot x + P_2 \cdot (T - x)$
      Notes:
      x = quantity of the first product
      $T - x$ = quantity of the second product
      $P1$, $P2$ = price of each product
3. Profit Function (Profit / π)
   Profit is the difference between revenue and expenses:
   $\pi(x) = TR(x) - TC(x)$
   Example of substitution (for a single product):
   $\pi(x) = (P \cdot x) - (FC + VC \cdot x)$
   Simply put:
   $\pi(x) = (P - VC)x - FC$
4. First Derivative for the Maximum Point
   To find the maximum profit, the first derivative is used:
   $\pi'(x) = 0$[8].
   Notes:

- If $\pi(x)$ is linear (as in the example above), then:
  a. There is no maximum point within the domain
  b. The maximum value occurs at the production limit (e.g., maximum capacity)
- If $\pi(x)$ is quadratic, then:
  a. The maximum point can be found from the first derivative
  b. It can also be tested using the second derivative

3. RESULTS AND DISCUSSION

The next section is the results and discussion. This section will analyse the calculations appropriate to the data processing procedures and supplement them with the data obtained by the researcher. After conducting the analytical calculations and obtaining the results, the next step is to discuss the results.

3.1. Results

The author obtained the research results necessary for the study. The data collected included capital, selling price per portion, and product capacity. The author will present the data using tables.

Table 1. Daily Production Costs of UMKM *Nasi Lengko* Trader A

SN	Data Types	Value
1	Capital	Rp. 101,000
2	Selling price per portion	• Lengko Rice + Egg: Rp. 10,000 • Lengko Rice: Rp. 5,000
3	Product Capacity	• Lengko Rice + Egg: 5 portions • Lengko Rice: 15 portions

Table 2. Daily Production Costs of *Nasi Lengko* UMKM Trader B

SN	Data Types	Value
1	Capital	Rp. 200,000
2	Selling price per portion	Rp. 10,000
3	Product Capacity	40 portions

Maximum Profit Analysis Calculation

a. Trader A

Variable Definition:

Based on the data, the production capacity is:

- *Nasi Lengko* only: 15 portions
- *Nasi Lengko* + Egg: 5 portions
- Total Capacity: 20 servings

Determine:

- x = number of portions of *Nasi Lengko* (Rp. 5,000)
- y = number of portions of *Nasi Lengko* + egg (Rp. 10,000)

Due to the total capacity of 20 servings:
$y = 20 - x, 0 \leq x \leq 15$

Finding the Income Function (TR):

$TR = 5000x + 10000y$

Substitution $y = 20 - x$:

$TR = 5.000 \cdot x + 10.000 \cdot (20 - x)$

Simplify:

$TR(x) = 5.000x + 200.000 - 10.000x = -5.000x + 200.000$.

Finding the Total Cost Function (TC):

$TC = FC + VCx \cdot x + VCy \cdot y$

$TC = 101.000$

Variable costs per portion (raw materials, spices, eggs, packaging, oil, gas, and labour) are included in the cost function to reflect actual economic conditions.

Finding the Profit Function (□):

$\pi(x) = TR - TC = (-5.000x + 200.000) - 101.000 = -5.000x + 99.000$.

Finding the Derivative and Optimisation Derivative of □ with respect to □:

$\pi'(x) = d(-5.000x + 99.000)/dx = -5.000$ (constant negative).

Since the profit function decreases as □ increases, the maximum occurs at the lower boundary of the domain. $\pi' < 0$

Lower limit of domain: (no portion of *Nasi Lengko*; all portions are Rice + Omelette)

$x* = 0$

Finding the Maximum Profit Value Enter □ ∗ = 0 into □(□):

$\pi(0) = -5.000 \cdot 0 + 99.000 = Rp\ 99.000$.

Based on the form of the profit function obtained, the first derivative □′(□) has a constant value so that it does not produce an interior critical point. Thus, the maximum value obtained is not the maximum point of the derivative result, but rather the maximum at the domain boundary (end-point), namely when all capacity is allocated to the menu with the highest selling price [9].

Verification (normal way):

If then: $x = 0,\ y = 20$

$TR = 5.000 \cdot 0 + 10.000 \cdot 20 = 200.000$.

$TC = 101.000$.

Profit = $200.000 - 101.000 = 99.000$.

Maximum profit occurs when all capacity is allocated to the menu with the higher selling price (This is the maximum at the domain limit. $x = 0$).

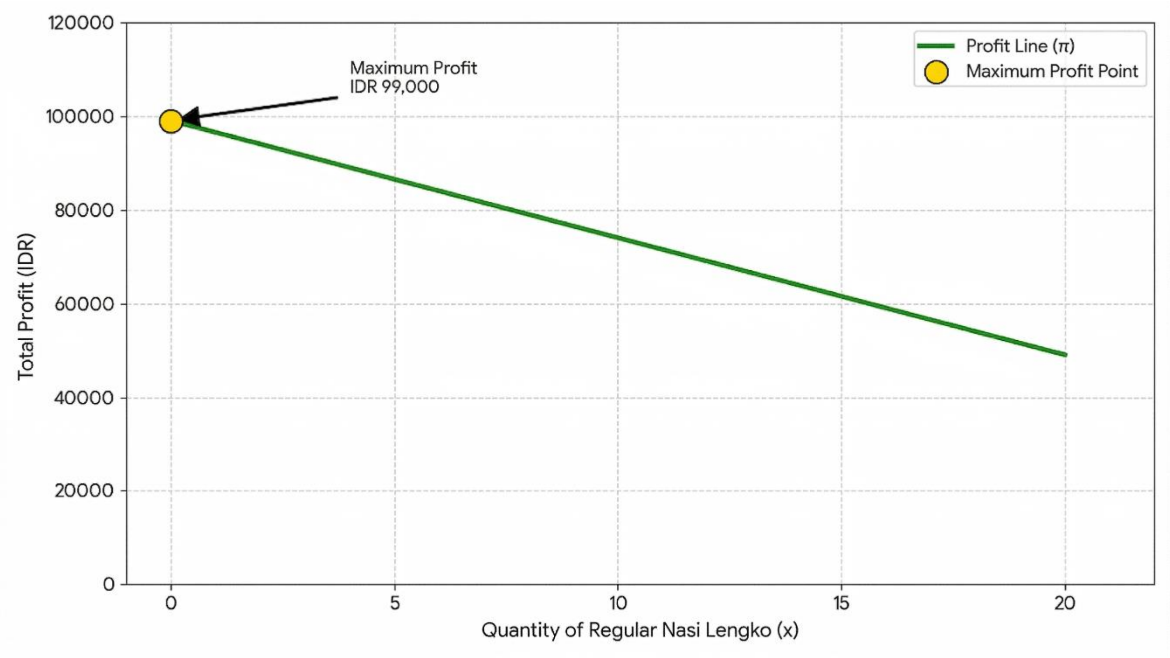

Figure 1 Profit Optimisation for Nasi Lengko Trader A

Graph Explanation:

- Break-Even Point (Top Left): The point of maximum profit is Rp 99,000. This point is reached when you sell 0 regular *Nasi Lengko*, meaning the entire capacity of 20 portions is filled with *Nasi Lengko* + Egg.
- Green Line (Profit Trend): This line slopes downward to the right. It visualises your calculation: as the number of regular rice portions increases, total profit decreases because the profit margin for regular Rice is smaller than that for Rice with Egg.
- X-Axis: Shows the number of portions of Regular *Nasi Lengko*. The further to the right (the more regular Rice), the lower the graph goes.

This visualisation shows that, economically, Trader A will achieve its best financial performance if it focuses on selling the menu with Egg (the highest point on the graph).

b. Trader B

Variable Definition:

n = number of portions sold (maximum 40).

Finding the Revenue Function (TR):

$TR = 10.000 \cdot n$

If full capacity ():$n = 40$

$TR = 10.000 \times 40 = Rp\ 400.000.$

Finding the Total Cost Function (TC):

Because all capital is used for daily production costs:

$TC = Rp\ 200.000.$

Finding the Profit Function (□):

$\pi(n) = TR - TC = (10.000 \cdot n) - 200.000$

To find the maximum value, differentiate □ with respect to:n

$\pi'(n) = d(10.000 \cdot n - 200.000) / dn = 10.000$

Since (is a positive constant), the profit increases as n increases. This means that the maximum profit occurs at the upper boundary of the domain, namely

$\pi(n) = 10.000 > 0$

$n = 40$

Finding the Maximum Profit Value

$\pi(40) = 10.000 \times 40 - 200.000 = 400.000 - 200.000 = Rp\ 200.000.$

Verification (normal way):

- Income: Rp 400.000
- Cost: Rp 200.000
- Profit: Rp 200.000

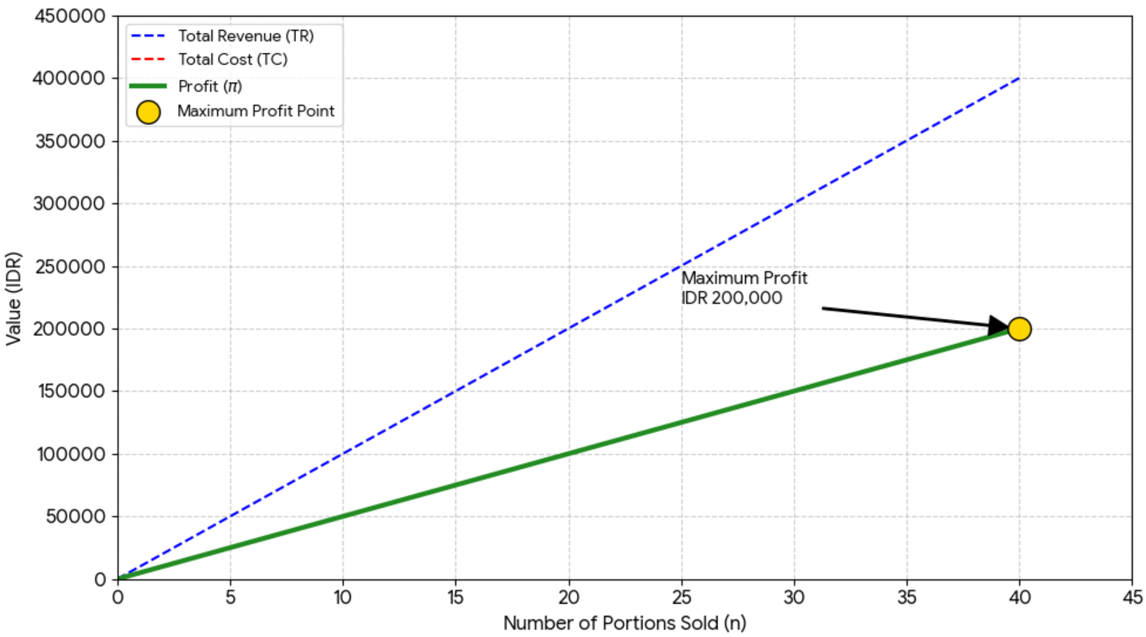

Figure 2. Profit Optimisation for Nasi Lengko Trader B

The graph below illustrates the relationship between the number of portions sold (n) and total revenue, total cost, and net profit.

- Total Revenue (TR): The blue line shows gross revenue increasing by Rp. 10,000 per portion.
- Total Cost (TC): The red line shows the production costs of Rp. 5,000 per portion.
- Profit (π): The thick green line shows net profit (TR - TC). Since the profit margin per portion is Rp. 5,000 (positive), the more portions sold, the higher the profit.

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- Maximum Profit Point: The gold dot indicates the maximum profit of Rp. 200,000 achieved at full capacity, which is 40 portions.

3.2. Discussion

a. Trader A

In calculating the maximum profit value of *Nasi Lengko*, Trader A uses the domain limit of the number of portions of *Nasi Lengko* (5,000), which is 15 portions. The optimisation of the application of derivatives on x shows that the maximum profit is achieved at □ = 0. Then, the maximum profit = IDR 99,000/day with a combination of 0 portions of Nasi Lengko and 20 portions of Rice + omelette. This means that Trader A can focus more on the portion of *Nasi Lengko* on a more expensive menu to increase total profit within the domain limit, and if he wants to increase production, he will still see an increase in profit. Trader A's profit function does not have a maximum point of derivative results because the slope of the first derivative is a constant negative value, so no x value makes the derivative = 0. So the maximum profit occurs at the domain limit, not at the critical point.

Thus, the results for Merchant A differ from those of the study titled “Analisis Keuntungan Maksimum pada UMKM Rumah Makan Kita Menggunakan Aplikasi Turunan.” This is because, in Merchant A’s results, maximum profit is achieved at the domain boundary rather than at the critical point, even when production volume can still be increased and prices raised. Meanwhile, in the aforementioned literature, the profit value occurs when the production quantity equals the critical point; if the production quantity is increased, the profit decreases [4].

Furthermore, when comparing Merchant A’s profit calculations with the study “Aplikasi Diferensial dalam Menghitung Analisis Keuntungan Maksimal pada UMKM,” For Merchant A, both products still generate a profit, and even when the price of one product is raised, a profit is still achieved. This differs from the study, in which only a few products achieve a profit, while the rest do not due to selling prices and production quantities [5].

b. Trader B

In selling *Nasi Lengko*, Trader B spends capital of Rp. 200,000 with a selling price of Rp. 10,000 per portion of *Nasi Lengko*; the maximum profit is achieved at a production volume of 40 portions. So, the maximum profit Trader B can obtain from *Nasi Lengko* is Rp. 200,000. Then, based on the calculation, all are positive; Trader B should sell *Nasi Lengko* at full capacity to achieve maximum profit.

This study takes a different direction from the study "Analisis Keuntungan Maksimum UMKM Rumah Makan Kita Menggunakan Aplikasi Turunan (Deveratif)," which found that increasing production actually decreases profits. In this study, especially in the case of Trader B, increasing production actually increases profits because the profit function is linear [4]. Meanwhile, the study "Aplikasi Diferensial dalam Menghitung Analisis Keuntungan Maksimal pada UMKM" emphasised that overproduction and excessively high selling prices can hinder the achievement of maximum profits [5].

Therefore, both previous studies and this study emphasise the importance of regulating production quantities and selecting menus to maximise profits.

4. CONCLUSION

This study employs a mathematical approach using cost and revenue functions and their first derivatives to determine the point of maximum profit from available data. In the Trader A case, maximum profit is achieved when production capacity is allocated to the menu item with the highest selling price, namely *Nasi Lengko* with Egg. Meanwhile, in the Trader B case, the profit function is linear, resulting in increasing profits as the quantity sold increases.

However, this study has limitations due to the incomplete availability of variable cost data, resulting in a cost function based solely on fixed costs. The primary limitation of this study is the small sample size. The researcher included only two *Nasi Lengko* vendors in both the population and the sample, so the results are insufficient to represent the entire population of *Nasi Lengko* vendors in Cirebon. The limited sample size may reduce the representativeness of the findings regarding the conditions and characteristics of other vendors. Additionally, this study has weaknesses in its data collection. The data used is not yet sufficiently complete and detailed, which may hinder the accuracy of the analysis and the interpretation of the research results.

Thus, the recommendation for future researchers is to use a larger, more diverse sample, such as by collecting data across multiple regions, to ensure more representative results and stronger data. Future researchers are also encouraged to collect more comprehensive, in-depth data and to employ a variety of data collection methods, including direct observation, in-depth interviews, and structured questionnaires. These steps are expected to provide a more comprehensive and accurate picture of conditions in the field. Therefore, while this study provides an initial overview of the application of derivative concepts in profit analysis, it does not yet offer a comprehensive analysis of traders' economic conditions. Future research could use more detailed variable-cost data to ensure the resulting mathematical models are more accurate.

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